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A NATURAL GAS EXPLOSION NEAR WALDRON, IND.

Introduction.—On the eleventh day of August, 1890, a natural gas explosion of much violence occurred near Waldron, in Shelby county, Indiana. The ground was disturbed, and fractures, crevices, and craters were formed over an area of several acres.

Many newspaper accounts of the explosion were published. In most cases these were greatly exaggerated. Bare mention of the occurrence was made by E. T. J. Jordan, natural gas supervisor of Indiana, in his report to the state geologist, in 1891.[1]

In discussing a violent natural gas explosion that occurred at Coffeyville, Kan., on July 26, 1894, Haworth refers to a similar explosion that had occurred in Indiana, giving the locality as Kokomo; he says:

> One similar occurrence is known in the gas field of Indiana, near Kokomo, in which a fissure was formed in the solid limestone from which natural gas escaped with explosive violence and caught fire from a burning log heap near by.[2]

Haworth refers here to the Shelby county explosion, which did not occur near Kokomo, however, but took place about one hundred miles south and slightly east of that city. Neither was a visible crevice formed in solid limestone, as the explosion occurred in an area that was covered with soil and gravel, though

[1] *Indiana Department of Geology and Natural Resources, Seventeenth Annual Report*, p. 338. Indianapolis, 1892.

[2] *Kansas University Quarterly*, Vol. IV, p. 95. (Mr. Haworth's information concerning the Indiana explosion was obtained from Mr. William Moore, of Kokomo.)

limestone crops out near by (at *L. S.* Fig. 1) and also ¼ mile up stream from the area of the main explosion.

Later (1899), in a report upon the Waldron shale, made to the state geologist of Indiana, Mr. J. A. Price states briefly such facts concerning the Shelby county explosion as could be gleaned from statements of the citizens of the neighborhood at that time.

Except for the brief notices mentioned above no account of this interesting explosion has appeared in any scientific publication, so far as the writer is aware, and it is with a desire to place on record the salient facts concerning it that the following map, figures, and paper are published at this time.

The writer visited the locality on August 15, 1890, four days after the explosion occurred, while its effects were still fresh, and while the gas escaping from the crevices and craters still burned intermittently when ignited. From notes taken at the time, a map was prepared and a short account of the explosion was written, and read on November 7, 1890, before the Indiana University Scientific Society. The map and facts of the present paper are taken from the paper read, but not published at that time.

The figures are reproduced from photographs obtained from J. T. Schaub, Hope, Ind., and Everett Ayers, of Germantown, Ind.

Location.—The explosion occurred near the center of section 7, 11 north, 8 east; the affected area is two and a half miles south, slightly west of the village of Waldron, and two and a half miles west, slightly south of the village of St. Paul. Gas wells were reported to be producing at the time from both of these villages.

Owing to the fact that the Ogden Cemetery was at the edge of the disturbed area, the outburst of gas was known locally as the Ogden Cemetery "earthquake," "gas explosion," and "blow-out."

A total area of about ten acres was affected. The most violent explosion was limited, however, to a space of about two acres at the east side of the locality affected, and is shown approximately by the Nos. 1, 3, 5, and 6, Fig. 1. The topog-

raphy and relations of the area can be best understood by reference to Fig. 1.

The area that was shaken up lies at the south side of Big Flat Rock River or Creek, in an almost half circle bend formed by that stream, and is comparatively flat creek "bottom land"

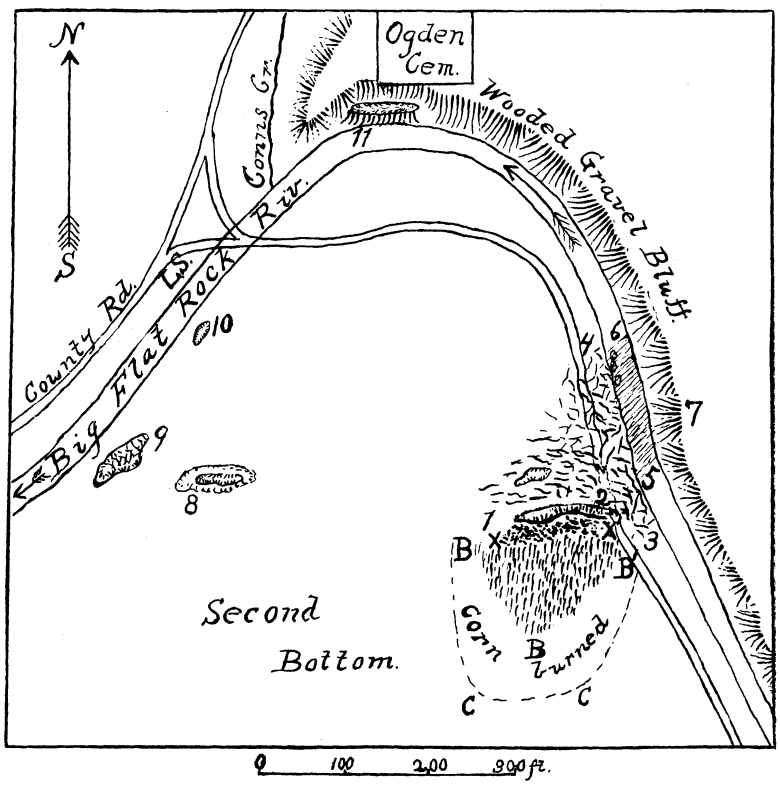

FIG. 1.—Map of the area affected by the Ogden Cemetery gas explosion, in Shelby county, Ind.

made up of alluvium. The south side of this area, marked "second bottom," (Fig. 1) is slightly higher than the portion, included by the Nos. 4, 3, 1, 8, 9, 10, and 11, in which the explosion occurred. At the time of the explosion growing corn covered the second bottom.

At the east and north side of the stream is a wooded bluff, of glacial gravel and clay, about forty feet high; this bluff was

covered with forest trees at the time of the explosion. There were also a few trees of considerable size bordering the creek on the side across from the bluff.

Geologic relations.—Most of the area affected by the explosion is covered by alluvial soil or gravel; only one exposure of rock in place occurs (viz., at *L. S.*, Fig. 1). Rock in place (belonging to the Niagara group) outcrops one-fourth mile up stream from the area of the main explosion, and in the affected area the limestone is probably only ten or twenty feet below the surface. The strata of this region lie approximately flat.

The rocks which underlie the region are shown by the following section of the strata passed through in drilling the gas well at C. J. Bickhart's mill, about two miles east of Ogden Cemetery.

SECTION AT BICKHART'S MILL.[1]

1.	Clay	4 feet
2.	Limestone (Niagara, in part at least)	86
3.	Shale (Hudson River)	774
4.	Limestone (Trenton)	22
	Total	886

Gas with a pressure of 335 lbs to the square inch was struck at nine feet in the Trenton limestone.

An irregularly bedded, porous conglomerate which gives off a fetid odor from a freshly broken surface is exposed for 150 feet along the east bank of the river about 150 yards above the area in which the main explosion occurred. This conglomerate is made up for the most part of coarse sand and small pebbles, but it contains some bowlders at least eight inches in diameter; it dips 30°, N.30°E., and is overlain by soft glacial clay and gravel. This is probably a locally hardened glacial deposit, and, if there is any connection between it and the gas explosion, that connection is not apparent to the writer.

Character and results of the explosion.—The explosion occurred about 9 o'clock, on the morning of August 11; it does not appear to have been accompanied by any violent report, for the attention of the people living in the neighborhood was first

[1] Reported by C. J. Bickhart in 1902.

FIG. 2.—View up the river from near the point 4 in Fig. 1. The county road which was made impassable by the explosion is seen at the right of the center of the picture. The trees that are barren of leaves had their leaves and smaller twigs burned off. The trees at the left of the picture are on the east side of the river and had their leaves browned by the heat. Most of the people in the background are standing on the earth blown out at the south side of the main fissure, x–x^1, Fig. 1. Blown down corn is barely shown at the right end of the picture. At the left end trees blown down by the explosion are shown, as is also the elevated bottom of the creek, where water stood prior to the explosion. From a photograph taken August 12, 1890.

attracted by a roaring or whizzing sound like the escape of steam from a boiler, but much louder. Upon looking toward the river, a sheet of flame was seen extending about 250 yards along the east side of the river bend. Regarding the height of the flame, estimates of those in sight at the time varied between 150 and 300 feet or more.

The height and intensity of the flame were sufficient to sear the leaves on the trees standing on the gravel bluff east of the river, and to completely burn off the leaves and small twigs from the trees standing near the fissures through which the gas escaped.

The vegetation around the openings (8, 9, 10, Fig. 1) at the west side of the area showed that the gas that escaped from those openings did not burn.

The roaring and flame continued at their height for about fifteen minutes, and then gradually subsided, and the gas burned from only a few of the crevices that had been formed.

The explosion had opened up a great number of crevices in the soil near the river bank (3–4, Fig. 1. See Fig. 2 also). When the ground was visited by the writer, these fissures varied in width from a few inches to four or five feet, with a like variation in depth, the shallowness being caused by the caving in of the soft soil at the sides and from the top.

Some of the fissures had evidently been formed by the upheaval, or depression, of the surface which had been elevated in some places, and in others had sunk down as much as four or five feet. The larger fissures, however, showed that they had been formed by the soil being blown out from below, the blown-out material being piled up at the sides of the fissures.

The character of the fissures is shown by Fig. 2, which shows also the "heaved up" condition of the surface. The center of the public road is shown in the foreground at the right side of Fig. 2. At this place (corresponding to the point 2 in Fig. 1) the road was so twisted and fissured as to be impassable.

The river bed from 5 to 6, Fig. 1, had been raised several feet, leaving the bottom exposed where water had stood before, while the west bank of the stream, from 3 to 4, Fig. I, had sunk

several feet. It was reported that the river flowed into the crevices between 3 and 6, Fig. 1, for some hours after the explosion.

Forest trees near 3, 5, and 11, Fig. 1, had been blown up by the roots and blown several (10–20) feet from where they had stood. The leaves on the trees and bushes from 5 to 11, Fig. 1 (about two hundred yards) were seared by the heat. On the west side of the creek from B' to 4 the smaller branches (and in some cases the bark) of the trees were entirely burned off.

FIG. 3.—View from the east side of the stream below 7, Fig. 1, looking westward across the river towards the point where the explosion was most violent. The trees shown in the water were blown up by the explosion, as were also the piles of earth along the river bank on which the figures stand.

Many of the trees were completely plastered from bottom to top with a fine mud, unlike anything exposed at the surface. This mud must have been thrown out with great force, as was shown by the manner in which it was plastered upon the trees and corn of the affected area. Lying about the fissures and over the surface were large quantities of this mud, which, upon drying, hardened somewhat and was easily cut into various designs, which were sold as souvenirs to visitors who came in great numbers to the locality.

Examined under the microscope, this mud is seen to be composed of an impalpable powder, such as might have been formed by direct precipitation of its constituents from solution.

ANALYSIS OF THE MUD BLOWN FROM THE CREVICES.

A. J. Cox, analyst.

	Per Cent
Lime (CaO)	13.4
Magnesia (MgO)	4.30
Iron oxide (Fe_2O_3)	15.45
Silica and insoluble silicates	49.75
Carbon dioxide (CO_2)	12.10
Water	5.6
Total	100.6

When seen by the writer, the principal fissure formed by the explosion (see 1, 2, Fig. 1) was between fifty and one hundred feet long, about five feet wide, and five feet deep. This crevice had evidently been much deeper, but when the gas ceased escaping under sufficient pressure to keep it open, loose earth had caved into it and partially filled it. The fissure extended almost east and west, and was along the foot of the slope, between the second bottom and the lower ground. At its south side was a mass of earth, x–x', from five to ten feet high, that had been blown from the fissure.

A field of corn was growing south of the main fissure at the time of the explosion. About an acre of this corn, B, B', C, C, Fig. 1, was burned brown by the heat, while half of this burned portion, B, B, B', Fig. 1, was blown flat upon the ground, and much of the blown down corn was plastered with mud. The corn was blown over toward the south, showing that the force came from the fissure at the north side. Some of the blown down corn is shown at the right end of Fig. 2.

At 11, Fig. 1, a slice of the gravel bluff was shaken down by the explosion, and some trees were blown up by the roots.

Irregular openings or craters were blown out at 8, 9, 10, Fig. 1, but the explosion was not so violent here as at the east side of the affected area.

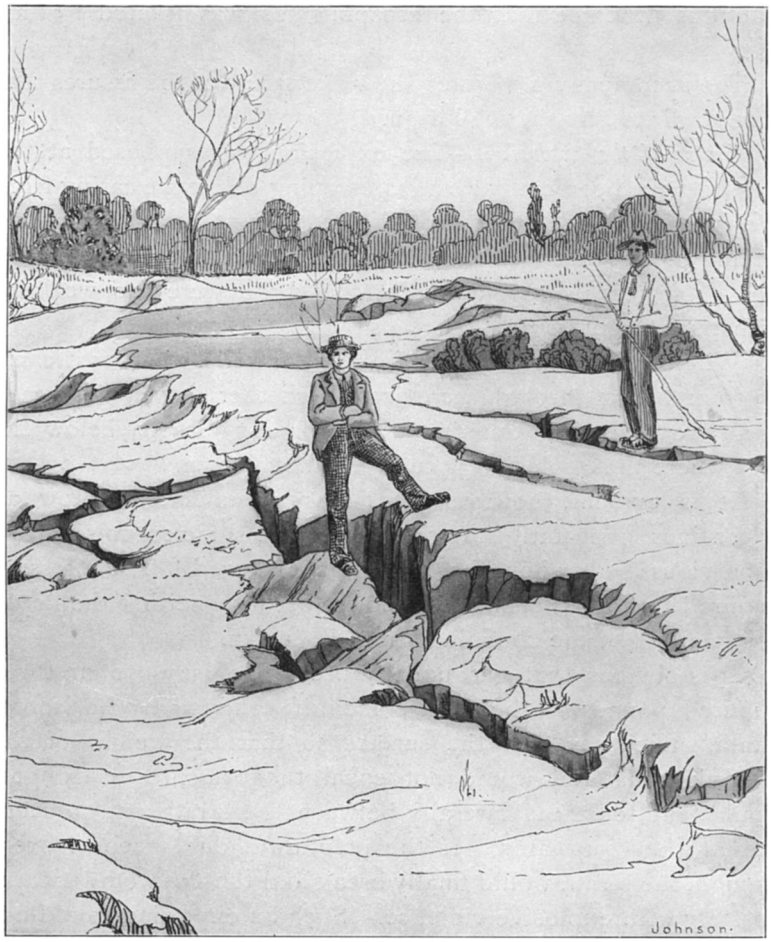

FIG. 4 —One of the fissures evidently formed by the earth cracking apart, owing to upheaval rather than by the earth being blown out. The piles of earth in the background of the picture correspond to x–x^1 of Fig. 1 and are at the south side of the main fissure, 1, 2 of Fig. 1.

When visited by the writer, four days after the explosion occurred, a little gas was escaping from many of the fissures, and this would burn for a short time when ignited.

It was reported by the citizens of the neighborhood that a fire had been burning in brushwood on a small island in the river about 150 yards above the main fissure previous to the explosion,

and it is probable that the escaping gas was ignited by this fire.

The accompanying figures show the nature of the fissures that were produced by the explosion.

Cause of the explosion.—The explosion was supposed at the time to have been caused by gas escaping below the casing from the wells at either St. Paul or Waldron, or at both places, and finding its way between the strata to the point where the explosion took place, at which point the strata were too weak to withstand the pressure.

Whether the gas did come from these wells, whether it came up from below through a crevice, or whether it was generated at no great depth in the strata, more or less directly below the area where the explosion occurred, is not known.

It is evident, however, that gas accumulated below an impervious layer until the pressure became sufficient to rend this impervious bed, when the explosion followed. The pressure required to do this cannot be known, because neither the depth nor strength of the confining strata is known.

It is obvious that gas, under a pressure of say two or three hundred pounds to the square inch, if confined by horizontal strata, sufficiently near the surface so that the weight of the overlying material would not equal the pressure of the gas, would tend to spread laterally between the strata, and to cause these to bend upwards. If the pressure should become great enough, the strata would finally break and the gas would escape, possibly with explosive violence. Such an explosion would not necessarily indicate that a large supply of gas was involved, for a small quantity would exert as great a pressure to the square foot as a larger one.

The area affected by the Ogden Cemetery explosion covered about ten acres; the pressure on this surface at 250 pounds[1] per square inch would have been 36,000 pounds to each square foot of surface.

Taking the weight of the shales and surface soil as 175

[1] The "rock pressure" of the gas in some portions of the Indiana field in 1890 was over 300 pounds to the square inch.

pounds to the cubic foot, this pressure would have equaled the weight of the overlying materials at a depth of 205 feet.

Assuming the pressure of the gas to have been 250 pounds to the square inch, then the strata which enclosed the gas prior to the explosion may have been anywhere between the surface and a depth of 205 feet.

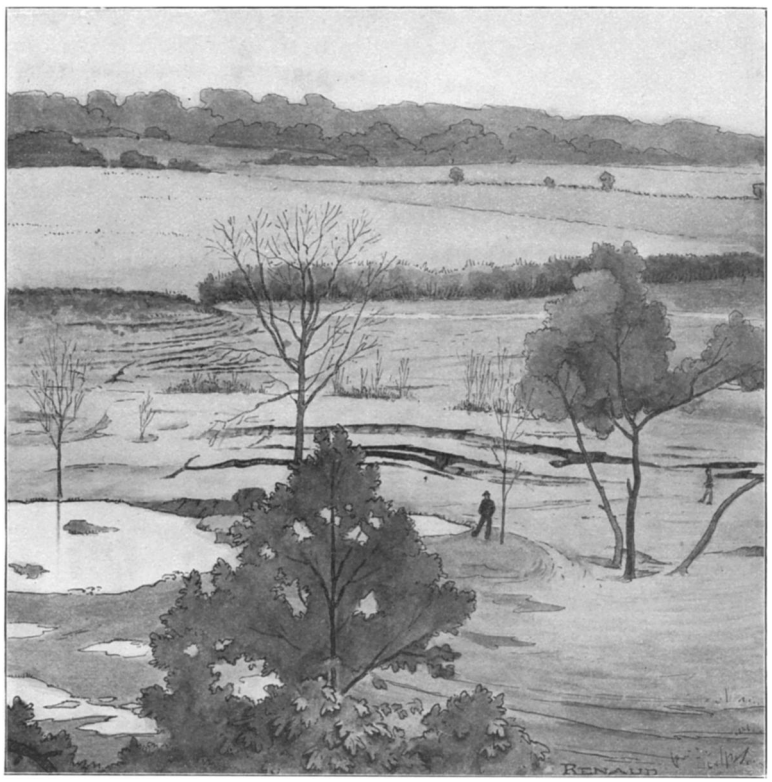

FIG. 5.—View looking southwestward from the top of the bluff at 7, Fig. 1. Prior to the explosion the water of the stream flowed over the surface of the ground shown in the right foreground of the picture. (From a photograph.)

In closing, attention is directed to the fact that the locality in which the Ogden Cemetery explosion occurred is near the southwestern edge of the natural gas area of Indiana, and that

the Trenton limestone, the great gas producing formation, is about 850 feet below the surface at this point.[1]

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STANFORD UNIVERSITY,
August 25, 1902.

[1] At Geneva, three and one-half miles southwest from Ogden Cemetery, Trenton rock (the gas producing bed of the region), was struck in a gas well at a depth of 832 feet. At Bickhart's mill, about two miles east of the cemetery, Trenton was struck at a depth of 864 feet, with gas at a pressure of 335 pounds to the square inch.